

wheel and wheeled carriage, and of the ballistic pendulum. Prof. Price calls the inventor Captain Robins; but, according to the preface of his "Mathematical Tracts," Robins was of Quaker extraction (like so many other students and inventors of warlike instruments), and his only military employment was as chief engineer of the East India Company, in planning and carrying out their fortifications.

In chapter vi. the rotation of a rigid body about a fixed point is discussed, with applications to the three important problems of motion under no forces with Poinso't's geometrical representation, the motion of the top or gyrostat, and the precession and nutation of the earth's axis. These problems illustrate very strikingly the great increase in complication when we go from plane motion to motion in space. The figure of the herpolhode, on p. 251, shows points of inflexion; but, as the author mentions in § 295, these points of inflexion cannot exist in Poinso't's herpolhode. An elegant geometrical demonstration is given on p. 379 of Sylvester's extension of Poinso't's representation, where confocals to the momental ellipsoid are made to roll upon parallel planes; and now it is possible in certain corresponding herpolhodes for points of inflexion to make their appearance; the analytical and geometrical discussion of this problem has engaged the attention of de Sparre and Hess.

We mentioned at the outset that the author did not permit himself the use of elliptic functions; but apparently he could not resist the temptation of introducing them in the complete solution of Poinso't's motion, the simplicity and elegance of the representation being so great. In the separating case, when the modulus of the elliptic functions becomes unity, the introduction of the corresponding hyperbolic functions would have exhibited an analogous symmetry.

By considering the elliptic functions as defined by plane pendulum motion, some of the results in the motion of the top or gyrostat could have been exhibited by comparison with a plane pendulum; but it must be confessed that the simplicity is not maintained when we investigate the projection of the motion on a horizontal plane, without we introduce functions invented by Hermite, of a higher degree of complication.

In the discussion of precession and nutation, a simplification can be introduced by making use of the observed fact in determining the latitude, that the deviation of the axis of rotation from the axis of figure, although certainly existing, is quite inappreciable in the case of the earth; so that the axes of figure, of rotation, and of angular momentum may be taken as coincident. With this approximation the pole of the earth follows a point 90° in longitude behind the sun or moon with a certain velocity; and now the rest of the calculation of precession and nutation becomes a kinematical problem.

Chapter vii. discusses interesting and important problems of small oscillations and of bodies rolling on each other, *e.g.* of a billiard ball on the table; and chapter viii., on relative motion, is important as showing how far we are justified in applying our dynamical equations to the problems going on around us, considering that they take place on the surface of the earth, which is moving in a complicated manner in space. The corresponding elementary discussion in Maxwell's "Matter and

Motion," on the ideas of relative motion, and the modification of the principles of dynamics to make them rigorous, is well worth attention at this point.

The deviation from the vertical of a body let fall down a deep mine, of a projectile from the vertical plane of fire, and the rotation of the plane of oscillation of Foucault's pendulum, are discussed as illustrations of the influence of the earth's rotation in modifying a dynamical question; but considering how slight a disturbing cause, such as a current of air, would be sufficient to mask the effect, we believe that these effects have not yet really been observed.

In Foucault's pendulum a very slight jockeying can make the thing go as we wish; while with artillery fire at long ranges the disturbing cause of deviation or drift quite overpowers any deviation due to the rotation of the earth. Theoretically, Foucault's pendulum, if set swinging in a plane through the rising moon, should continue to follow the moon; and roughly speaking, a shot fired at the rising moon should keep moving in the moving vertical plane through the moon, and would thus fall to one side of its original vertical plane of fire; in a range of twelve miles, and a time of flight of one minute, this deflection would, in the latitude of Shoeburyness, amount to about 71 yards, out of about 1000 yards observed average lateral deviation.

A few simple problems on the vibration of elastic threads and plates are given in chapter ix.; and chapter x., as already mentioned, is occupied by Prof. Donkin's contribution on Theoretical Dynamics.

Throughout the work good collections of illustrative examples are introduced, to test the student in his grasp of the principles given immediately before. If we might make a slight criticism, we should suggest the introduction of some arithmetical exercises on these problems, taken from examples in real life; for, as Sir William Thomson insists, it is from arithmetical applications that the student obtains a real grasp of dynamics; the examples given here only testing his algebraical and geometrical power.

In conclusion, we congratulate the student of mathematics at Oxford on the possession of such an admirable text-book, fully brought up to date in the latest developments.

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ANNALS OF THE ROYAL BOTANIC GARDEN, CALCUTTA.

Annals of the Royal Botanic Garden, Calcutta. Vol. I.

Appendix—(1) "Some New Species of *Ficus* from New Guinea," by George King, F.R.S., &c., Superintendent of the Royal Botanic Garden, Calcutta. (2) "On the Phenomena of Fertilization in *Ficus Roxburghii*, Wall," by D. D. Cunningham, F.L.S., &c., Surgeon-Major, Bengal Army. (Bengal Secretariat Press, 1889.)

ABOUT a dozen new species of *Ficus* are added here to Dr. King's valuable monograph of the figs of the "Indo-Malayan and Chinese countries," which occupies the whole of the first volume of the "Annals." It may be remembered that Dr. King proposed a modified classification of the species of *Ficus*, based upon characters indicating, in his view, the direction of evolution in the genus, beginning with a small group having pseudo-hermaphrodite flowers (*Palæomorphe*),

and ending with another small group (*Neomorphe*) remarkable for having di- or tri-androus male flowers, and the receptacles (fruit) borne in clusters, often very large, on the trunk and branches, sometimes at the very base of the trunk.

Curiously enough, although the other five groups or sections, into which King divides the genus *Ficus*, are all represented among the additional species from New Guinea, neither the oldest nor the newest is; but both are represented there by previously known species, and the *Neomorphe* by some of the most remarkable of the genus. Thus, imperfectly as the flora of New Guinea is known, there are indications of great age and variety. Noteworthy among the species figured in the present work is *Ficus hesperidiiformis*, King, belonging to the section *Urostigma*, which is characterized by having male, female, and "gall-flowers" intermixed in the same receptacles. *Ficus hesperidiiformis* resembles the familiar india-rubber tree, *F. elastica*, but the leaves are larger and the receptacles (fruit) very much larger; the ripe dry ones resembling small oranges, hence the specific name.

Dr. Cunningham's memoir on the fertilization of *Ficus Roxburghii* is an interesting and important contribution to the subject of reproduction, inasmuch as he arrives at some rather startling conclusions with regard to the plant in question.

The relations between certain insects, parasitic in the receptacles of the fig and caprifig, and in various other species of fig, and the fertilization of the flowers, has been investigated in recent times more especially by Dr. G. King, Mr. Fritz Mueller, and Count Solms; and particulars of their results, or conclusions, have been given from time to time in NATURE (vols. xxvii. p. 584, xxxvi. p. 242, and xxxix. p. 246). Nevertheless it may be well to repeat here some of the principal conditions and phenomena of the flowers of figs. In the first place it may be noted for unbotanical readers that the flowers of figs are very small and crowded all over the interior of the receptacle or fruit. Further, that the wall or substance of the receptacle is continuous and closed, except at the apex, where it is provided with a number of closely overlapping scales, rendering ingress, and egress, without eating its way, impossible to any but a very minute insect. I say, without eating its way, because much depends upon whether insects can reach the interior of the receptacles and at the same time carry pollen with them; and writers on the subject, so far as I am aware, have not considered the probabilities of the earlier visiting-insects thus opening a channel for those following. I have also, in another place, suggested the possibility of the scales at the mouth of the receptacle being loosened at the receptive period, and Mr. C. B. Clarke tells me that he has actually observed this to be the case.

The flowers are of four kinds—namely, male, female, neuter, and gall; and they are variously associated, or separated, in different species of *Ficus*. There are indeed five kinds of flowers if we include the pseudo-hermaphrodite flowers of the group *Palæomorphe*. In the cultivated fig (*Ficus Carica*), the flowers are almost invariably all female; and the male flowers of this species are borne by the "caprifig" of the south of Europe and

Western Asia. Associated in the same receptacles with the male flowers, and covering the whole of the inside except a ring near the top, are the so-called gall-flowers. Structurally they are female, but instead of bearing seed they nourish the larva of an insect, and the perfect females of this insect are supposed to convey the pollen of the male flowers to the receptacles containing female flowers, the ovules of which are thereby fertilized. The presence of insects in figs seems to be general in the very numerous (500 perhaps) species spread all over the tropical regions of the earth; and the commonly accepted theory is that these insects, in return for the shelter and nourishment received, convey the pollen from the male to the female flowers, so that the association is mutually beneficial. At least this was the theory of Solms and Fritz Mueller. In the introduction to his monograph of the Asiatic figs, Dr. G. King says:—"The exact way in which the females are pollenized is a matter on which I cannot pretend to throw any light. I can only state the problem." Yet a little farther on he states that there can be no doubt that the insect developed in the gall-flowers in some way conveys the pollen of the males to the females in other receptacles, though he found it difficult to understand how this could be effected; and he informed the writer that he had never discovered the slightest evidence of the process, beyond the fact that seeds were formed.

At the instigation of Dr. King, Dr. Cunningham has thoroughly investigated the phenomena of fertilization in *Ficus Roxburghii*, and he arrives at the conclusion that pollen is never, or exceedingly rarely, conveyed to the female flowers, though good seed is abundantly matured.

Ficus Roxburghii is perfectly diœcious—that is, the two sexes are produced on different trees; and the fruit is borne in large clusters on the thicker branches and trunk often at the very base of the same, and extended on the ground.¹ The receptacles are similar in shape to those of the common fig, and from two to three inches in diameter, or sometimes nearly four inches; and the flowers are proportionately large, so that they are easily examined. It may be mentioned, too, that this species belongs to King's section or sub-genus *Neomorphe*, which, in our opinion, exhibits the latest stage in the evolution of the genus.

It would occupy too much space to follow Dr. Cunningham through his investigations, but it will suffice to give some extracts from his concluding remarks:—

"There can be little room for doubt that the phenomena indicate that, while the development of embryos in the female receptacles of the tree is essentially connected with the access of the insects to the receptacular cavity, it is yet normally independent of the introduction of pollen by their agency. The fact that the access of a single insect or of a pair of them only is sufficient to determine the development of ten or twelve thousand embryos, is in itself almost conclusive against the occurrence of any ordinary process of pollination. The obstacles through which a passage has to be forced ere the receptacular cavity is reached are of such nature and amount as to render it almost inconceivable that pollen should be introduced in sufficient quantity, and there is at the same time an absolute want of evidence to show that such introduction takes place. I have carefully examined very many receptacles at various periods shortly after access

¹ A photograph of a tree in fruit forms the frontispiece to the first volume of the "Annals of the Calcutta Garden."

of insects to the cavities, and have never been able to detect any evidence of general distribution of pollen over the stigmatic surface. Examination of individual flowers has given like results; in most cases it has been impossible to find any pollen within the receptacle or cavity, and in the few cases in which any was found it was represented by one or two shrivelled grains adherent to the corpses of insects. It must be borne in mind, too, that, if we accept the hypothesis that the development of the embryos is due to ordinary processes of pollination, we must assume not only that a single insect can convey many thousands of pollen-grains with it in spite of the excessive obstructions to access presented by the ostiolar plug, but that these grains are also methodically and economically distributed, for, unless each stigma were only allowed to appropriate a single grain, the amount introduced would have to be indefinitely multiplied.

"The most important evidence against the occurrence of pollination of any sort as a normal and essential event lies, however, in the fact that the embryo originates, as it does in undoubted cases of development, apart from pollination. The embryo, as a rule—for of course it is possible that pollination and normal evolution may occur in certain individual flowers—certainly arises as an outgrowth of the nucellar parenchyma, outside the embryo-sac, and not as the result of special evolution of any elements contained within in the latter. The embryo-sac up to the period of insect-access and of initial development of the embryo normally retains the characters of a simple uninucleate cell. There is no evidence of the formation of an oosphere, of synergidae, or of antipodal cells within it, and it is only subsequent to commencing evolution of the embryo that the primary nucleus is replaced by a large number of secondary ones, which are apparently related to the elaboration of food material for the growing embryo, when it gains access to the cavity of the sac.

"But if this be so, if pollination be unnecessary, why should the access of insects be essential to the development of embryos? The phenomena presenting themselves in connection with the male flowers of gall-receptacles appear to afford a clue to answering this question. It is just as impossible for the male flowers to come to perfection—just as impossible for perfect pollen-grains to be developed without the access of insects to the gall-receptacles—as it is for embryos to be developed in female ones under parallel circumstances.

"The development of embryos in *F. Roxburghii*, then, appears normally to be an asexual process dependent on hypertrophic budding of a specialized portion of the nucellar parenchyma, and it appears not improbable that the phenomenon is not peculiar to the species, but is the rule in the case of other figs also. This, of course, requires further investigation; but in the only instance in which I have yet had time to examine the matter—in the case of *F. hispida*—there can be no doubt that it is so."

From the foregoing extracts it will be seen that Dr. Cunningham insists on two extraordinary phenomena—namely, the impossibility of the formation of pollen in the absence of insects, and the formation of embryos by budding outside of the embryo-sac instead of sexual development. As to the first, improbable as it may seem, I am assured by two or three independent observers, who have had opportunities of testing Dr. Cunningham's work, that they have arrived at the same conclusions. As to the second, the asexual formation of embryos is not so very rare an occurrence, according to Strasburger in his elucidation of polyembryony and the so-called parthenogenesis. Then as to the whole, the phenomena would seem to point to the extinction of sexuality. The points are that the development of both pollen and embryo is due to a

stimulation of the tissues caused by the punctures of insects. Therefore Dr. Cunningham might with more propriety have entitled his paper "The Phenomena of Non-Fertilization." W. BOTTING HEMSLEY.

SYNONYMY OF THE POLYZOA.

A Synonymic Catalogue of the Recent Marine Bryozoa.
By E. C. Jelly, F.R.M.S. (London: Dulau and Co., 1889.

THIS is a work for which all students of the Polyzoa (Bryozoa) should be grateful. It supplies an undoubted want, and will greatly facilitate the investigation of the large and interesting class with which it deals.

Synonymy is certainly not an attractive element of natural history study. Indeed, anything of less intrinsic interest cannot well be imagined, and yet it has a specific value in relation both to morphological and systematic work, and it is of the first importance that it should be carefully determined. A just and accurate synonymy is of course an essential condition of a sound nomenclature; it is a key to the actual state of knowledge, and an index to the sources in which it must be sought, which is invaluable to the student. It is also a safeguard against duplicate and delusive names.

Miss Jelly's "Synonymic Catalogue of the Recent Marine Bryozoa" fills a vacant place. There is not, so far as we know, any work which occupies the same ground. "It aims," as the author explains in her preface, "at bringing into view all the names of *published* recent Bryozoa, with as full a synonymy as may be possible."

The fossil forms belonging to recent species, and these only, are included in the synonymy. The work, which bears the marks of careful and conscientious labour, brings before the student within small compass the entire series of published Polyzoan forms belonging to the recent fauna; supplies him with a reference to the book in which each species was first described and with the name of the writer who first described it; tracks it, as it were, however disguised by variety of name, from author to author, and so in fact furnishes an index to the whole range of the systematic literature.

The value of such a guide to the student of the Polyzoa must be at once evident. It economizes his labour; it enables him to enter upon original investigation with a full knowledge of what has been already done, and it saves him from adding to the weariness and perplexity of those who may follow him by multiplying duplicate names.

Within the last few years large additions have been made to the known species of Polyzoa, the diagnosis of which is distributed to a great extent through the biological journals of Europe and America. With all the care that he can exercise the student is continually liable to overlook some paper in some obscure periodical of which perhaps he has never heard, and, as a result, to add another name to the already burdensome synonymy. In point of fact, as a matter of convenience the synonymy of each class of any extent is worthy of separate and special treatment; and such a work as Miss Jelly has now supplied should be regarded as an essential part of the apparatus of the student who devotes himself to descriptive and systematic work.

We cannot but regret that Miss Jelly has abandoned